Special Article

# MASS PSYCHOGENIC ILLNESS ATTRIBUTED TO TOXIC EXPOSURE AT A HIGH SCHOOL

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**ABSTRACT**

***Background*** Mass psychogenic illness may be difficult to differentiate from illness caused by bioterrorism, rapidly spreading infection, or toxic substances. We investigated symptoms attributed to exposure to toxic gas at a high school in Tennessee.

***Methods*** In November 1998, a teacher noticed a "gasoline-like" smell in her classroom, and soon thereafter she had a headache, nausea, shortness of breath, and dizziness. The school was evacuated, and 80 students and 19 staff members went to the emergency room at the local hospital; 38 persons were hospitalized overnight. Five days later, after the school had reopened, another 71 persons went to the emergency room. An extensive investigation was performed by several government agencies.

***Results*** We were unable to find a medical or environmental explanation for the reported illnesses. The persons who reported symptoms on the first day came from 36 classrooms scattered throughout the school. The most frequent symptoms (in this group and the group of people who reported symptoms five days later) were headache, dizziness, nausea, and drowsiness. Blood and urine specimens showed no evidence of carbon monoxide, volatile organic compounds, pesticides, polychlorinated biphenyls, paraquat, or mercury. There was no evidence of toxic compounds in the environment. A questionnaire administered a month later showed that the reported symptoms were significantly associated with female sex, seeing another ill person, knowing that a classmate was ill, and reporting an unusual odor at the school.

***Conclusions*** This illness, attributed to toxic exposure, had features of mass psychogenic illness — notably, widespread subjective symptoms thought to be associated with environmental exposure to a toxic substance in the absence of objective evidence of an environmental cause. (N Engl J Med 2000;342:96-100.)



EPIDEMIC hysteria, also referred to as mass psychogenic or sociogenic illness and transient situational disturbance, was first described over 600 years ago, and it has been reported in a variety of cultures and settings.[1] Yet the subject is seldom addressed during medical or public health training. Mass psychogenic illness can be difficult to differentiate from bioterrorism, rapidly spreading infection, or acute exposure to toxic substances. Early recognition of and appropriate response to such incidents can have a substantial influence on the outcome. Epidemics of psychogenic illness often attract intense media attention and may have profound public health, social, and economic repercussions. Few descriptions of such epidemics have addressed the costs associated with the phenomenon.[2]

In November 1998, symptoms attributed to exposure to toxic fumes at Warren County High School in McMinnville, Tennessee, were widely reported in the news media. Numerous local, state, and federal government agencies investigated the incident; we took part in this investigation.

## CASE REPORT

Approximately 15 minutes after arriving at the high school on Thursday, November 12, 1998, a teacher noted a "gasoline-like" smell in her classroom; shortly thereafter she experienced headache, nausea, shortness of breath, and dizziness. Similar symptoms soon developed in several students in her room. As the classroom was being evacuated, more students reported symptoms, and a schoolwide fire alarm was sounded. The school was evacuated, and large numbers of students and staff members observed as firefighters, police, and emergency medical personnel from three counties responded to the alarm. The teacher who first reported symptoms (index teacher) and several students were transported to the hospital by ambulance, in view of other students and teachers. Classes were canceled, and that day, 100 persons (80 students, 19 staff members, and a family member who had come to the school to pick up a child) went to the local emergency room and reported symptoms they believed were associated with exposure at the school;

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38 of these persons were admitted to the hospital for observation overnight. The index teacher was among those hospitalized, but no explanation for her symptoms was found.

Over the next two days, the school was examined by the fire department, the local gas company, and state officials of the Occupational Safety and Health Administration (OSHA), none of whom could detect a problem. The school was reopened on Monday, November 16. On the morning of November 17, several students reported symptoms severe enough that ambulances were called, and the school was again evacuated and closed. That day, 71 persons with symptoms they thought were associated with exposure at the school went to the emergency room. After the second evacuation of the school, the principal called numerous government agencies, and an extensive environmental and epidemiologic investigation was undertaken. In this article we report the results of that investigation.

## METHODS

The initial investigation involved identifying cases of illness (defined as one or more symptoms believed to be associated with exposure at the school) and determining the epidemiologic and clinical characteristics of the affected group. Symptomatic persons were identified by examining records from the local hospital, the school, and the local health department. These persons were contacted for interviews and for blood and urine testing. Blood specimens were collected in nonsiliconized glass tubes, plastic tubes coated with liquid EDTA, and glass tubes coated with sodium oxalate and sodium fluoride. Urine was collected in sterile containers and frozen. Serum was placed in cryovials prescreened for contaminants. Specimens were sent to the Division of Laboratory Sciences, Centers for Disease Control and Prevention (CDC), for measurements of volatile organic compounds, persistent and nonpersistent pesticides, polychlorinated biphenyls, paraquat, and mercury.

The environmental investigation was coordinated by the Environmental Protection Agency, with assistance from the Agency for Toxic Substances and Disease Registry, the National Institute for Occupational Safety and Health, OSHA, the Tennessee Department of Health, the Tennessee Department of Agriculture, private contractors, and local emergency personnel. The investigation included an aerial survey to identify potential sources of contamination in the environment; an exploration of caves in the vicinity; evaluations of the school's air-handling, plumbing, and structural systems; studies of drilled core samples from various sites in and around the school; and analyses of air, water, waste, and wipe samples.

Environmental testing was conducted over several days, during a range of meteorologic conditions that were similar to the conditions during the episodes on November 12 and November 17. Over 220 air samples were obtained, beginning on the first day of the outbreak. Environmental samples were tested according to standards and criteria established by the Environmental Protection Agency.[3,4] Initial air monitoring was performed with the use of colorimetric tubes, flame-ionization detectors, photoionization detectors, radiation meters, and combustible-gas indicators. High-volume air samples were collected throughout the school with the use of Summa canisters and air samplers with polyurethane foam and OSHA Versatile Sampler mediums. Air samples were tested for carbon monoxide, hydrogen sulfide, carbon dioxide, volatile organic compounds, semivolatile organic compounds, pesticides, and polychlorinated biphenyls.

Five water samples, collected beginning on November 18 from cooling units, puddles of ground water, and a nearby spring and river, were examined for evidence of volatile organic compounds, semivolatile organic compounds, pesticides, and ethylene glycol. Material pumped from waste traps was tested for pesticides and volatile organic compounds. Eight wipe samples, collected from surfaces throughout the building beginning on November 13, were examined for volatile organic compounds, semivolatile organic compounds, pesticides, and polychlorinated biphenyls. Analysis of soil gas was performed on November 21 with the use of a direct-push core sampler and photoionization and flame-ionization detectors; specimens were tested for methane, ethane, and total ionizable hydrocarbons.

One month after the outbreak, a follow-up questionnaire was administered to students in the classroom of the index teacher and to students in 15 other, randomly selected classrooms throughout the school. The purpose of this survey was to compare persons who had reported illness and persons who had remained well in order to evaluate factors that may have contributed to the development of symptoms during the outbreak. Statistical analyses were performed with the use of two-sided chi-square tests[5] and Epi Info software.[6]

Costs associated with the outbreak were estimated on the basis of average charges for local emergency and medical services and the number of days when the school was closed. Person-hours were estimated by participating investigators. Laboratory costs were estimated by the directors of participating laboratories.

## RESULTS

In November 1998, the high school had 1825 students and 140 staff members. The building was four years old and was situated on land that had previously been farmed. The property was located outside a town with a population of approximately 11,000 persons. The county had one high school and one hospital.

At the time of the initial study, clinical information was available for 186 persons who reported symptoms that they believed were associated with exposure at the high school on or after November 12, 1998. Blood specimens were collected at the health department from 98 persons, and urine specimens from 100. Sixty-nine percent of the affected persons were female (Table 1), as compared with 52 percent of the overall population of students and staff at the school ($P<0.001$). A wide variety of symptoms were reported; the most common were headache, dizziness, nausea, drowsiness, chest tightness, and difficulty breathing. Although nearly one fourth of the affected persons reported fever, only one person had a temperature over 37.7°C (100°F) according to the medical records. Most symptoms resolved quickly with the administration of oxygen or the removal of the person from the school. None of the persons admitted to the hospital for observation overnight had complications, and all of them were discharged the following morning. The four persons with rash who were examined by health-department personnel had skin lesions that were consistent with the presence of tinea versicolor, acne, or contact dermatitis; the rashes were not suggestive of exposure to a toxic substance.

Of the 99 ill persons who responded to an open-ended question about what they thought had caused the illness, 67 (68 percent) believed that exposure to fumes or other toxic substances at the school had caused their symptoms, and 28 (28 percent) were not sure; 4 persons (4 percent) ascribed their symptoms to other causes. Ill persons in the initial group reported the onset of symptoms in at least 49 different locations throughout the school, including 36 classrooms, which were served by several independent air-handling systems. Six persons reported that they had

**TABLE 1.** CHARACTERISTICS AND REPORTED SYMPTOMS IN THE INITIAL GROUP OF 186 AFFECTED PERSONS.

| CHARACTERISTIC OR SYMPTOM | NO. OF PERSONS (%)* |
|---|---|
| Sex | |
| Male | 57 (31) |
| Female | 129 (69) |
| Student | 143 (77) |
| Staff member | 29 (16) |
| Other person | 14 (8) |
| Reported an odor† | 120 (65) |
| Symptom‡ | |
| Headache | 166 (89) |
| Dizziness | 131 (70) |
| Nausea | 121 (65) |
| Drowsiness | 106 (57) |
| Chest tightness | 92 (49) |
| Breathing difficulty | 91 (49) |
| Sore throat | 84 (45) |
| Burning eyes | 78 (42) |
| Cough | 71 (38) |
| Abdominal pain | 67 (36) |
| Nervousness | 62 (33) |
| Watery eyes | 58 (31) |
| Metallic taste | 53 (28) |
| Difficulty concentrating | 51 (27) |
| Rash | 46 (25) |
| Racing heart | 45 (24) |
| Fever | 41 (22) |
| Dry skin | 35 (19) |
| Wheezing | 32 (17) |
| Vomiting | 31 (17) |
| Sneezing | 31 (17) |
| Diarrhea | 17 (9) |

*Percentages may not sum to 100 because of rounding.

†An odor was reported in more than 31 locations.

‡Reported symptoms developed in more than 49 locations. Many affected persons had more than one symptom.

**TABLE 2.** RELATIVE RISK OF ILLNESS AMONG 284 STUDENTS IN THE INDEX TEACHER'S CLASSROOM AND IN 15 OTHER CLASSROOMS.*

| RISK FACTOR | ILL | NOT ILL | RELATIVE RISK OF ILLNESS (95% CI)† |
|---|---|---|---|
| | no. of students | | |
| Female sex | 55 | 111 | 2.44 (1.48–4.05) |
| Male sex‡ | 16 | 102 | 1.00 |
| Saw another ill person | 42 | 64 | 2.43 (1.62–3.66) |
| Did not see another ill person‡ | 29 | 149 | 1.00 |
| Knew at least one classmate was ill | 47 | 56 | 3.44 (2.24–5.28) |
| Did not know any classmate was ill‡ | 24 | 157 | 1.00 |
| Reported an odor | 44 | 46 | 3.51 (2.33–5.29) |
| Did not report an odor‡ | 27 | 167 | 1.00 |

*The 15 classrooms were randomly selected.

†CI denotes confidence interval.

‡This was the reference category.

become ill while outside, four while at home, and two while visiting students in the hospital.

Of the 186 ill persons in the initial group, 120 (65 percent) reported an unusual odor at the school. Over 30 different words were used to describe the odor. An odor was reported in more than 31 locations throughout the school.

Of the 178 persons evaluated at the local emergency room (100 on November 12, 71 on November 17, and 7 on other days), 96 were tested for carboxyhemoglobin, 80 for methemoglobin, 64 for sulfhemoglobin, and 39 for pseudocholinesterase; all test results were normal. Complete blood counts and chemistry profiles were obtained in several persons; in all cases, the results were normal. Tests performed on specimens sent to the CDC showed no unusually high levels of volatile organic compounds, persistent or nonpersistent pesticides, polychlorinated biphenyls, paraquat, or mercury.

Environmental evaluation of the school revealed no source of potential toxins that could have caused the outbreak of illness. The school's air-handling and plumbing systems were functioning normally. Several floor-drain traps in the index teacher's classroom (designed to keep gas out of the room) were noted to be dry and therefore not working; they were refilled after the first day of illness. Several grease and waste traps at various locations in the school were pumped out on subsequent days. The aerial survey and cave explorations revealed no apparent sources of toxins. None of the environmental samples tested showed evidence of any volatile organic compounds, semivolatile organic compounds, pesticides, ethylene glycol, polychlorinated biphenyls, or other potential toxins that could have caused the outbreak of illness. An air sample obtained from an air space enclosed between the outer and inner walls above the building's foundation showed traces of chlorpyriphos, a pesticide used during construction, which was an expected finding.

One month after the incident, 284 students in 16 classrooms (100 percent of those present in the classrooms at the time) responded to the follow-up questionnaire. Respondents included students from all grades; 58 percent were female. Seventy-one of the respondents (25 percent) had reported symptoms during the outbreak days (Table 2). On univariate analysis, illness was significantly associated with female sex, directly observing another ill person during the outbreak, knowing that a classmate was ill, or reporting an unusual odor at the school. Illness was not associated with age, grade in school, or location in the school before the alarm sounded.

Closure of the school resulted in a loss of 18,000 person-days. With 178 emergency room visits and 8 trips by ambulance, total charges for medical expenses were over $93,000 (average charge per visit, $400 for hospital services and $120 for physicians' services; average charge per ambulance trip, $150). The actual cost to the hospital was not determined. Toxicologic testing of clinical specimens required more than 200 person-hours of labor and $5,000 in laboratory supplies. Testing of environmental samples cost more than $9,000. It was estimated that more than 3000 person-hours were spent on field investigations, laboratory testing, and management of the incident, involving professional personnel from 12 government agencies, 8 laboratories, and 7 private consulting groups. Additional costs incurred by persons who may have sought care with private physicians and the costs of emergency services could not be quantified but were substantial. Media attention to the outbreak was intense, and the local newspaper published reports for more than a month after the school had been declared safe and had reopened.

## DISCUSSION

This outbreak has many of the features classically associated with mass psychogenic illness. Mass psychogenic illness has been defined as a constellation of symptoms suggestive of organic illness but without an identified cause in a group of people with shared beliefs about the cause of the symptoms.[7] It is a social phenomenon, often occurring among otherwise healthy people who suddenly believe they have been made ill by some external factor. Outbreaks of mass psychogenic illness affect girls and women more frequently than boys and men.[1] The incidents often occur after an environmental event or trigger, such as an odor,[1,2,8-10] and are frequently preceded by an index patient's illness and a prominent response by emergency personnel to the event or illness.[1,2,8,11-13] Contagion is increased by the proximity of affected and unaffected persons, reassembly of the group, and "line of sight" transmission.[1,8] Although symptoms may suggest an environmental cause, none can be identified quickly, and other persons who are putatively exposed do not become ill.

Such outbreaks often involve a very rapid spread of symptoms (frequently including hyperventilation or syncope), with minimal physical findings, and often occur in groups under physical or psychological stress. Dramatic and prolonged media coverage frequently enhances such outbreaks.[7,11,13-16] Many of these factors appear to have played a part in the outbreak at the high school in Tennessee. Intensive media attention probably heightened the collective anxiety and may have contributed to the second cluster of cases.

Despite an exhaustive evaluation, no environmental cause of the reported illnesses was identified. The normal laboratory findings and reassurances about the safety of the school were widely publicized. Nonetheless, more than one month after the outbreak, local media continued to report on persons with persistent headaches that they believed were related to exposure to a toxic substance at the school, and rumors of incompetence and coverup on the part of the government persisted. Some people believed that the investigation had simply failed to find the real cause of the illness. Paradoxically, in such circumstances, the observation of vigorous investigative activities may reinforce the suspicion that a genuine problem is being covered up. Persistent investigation also increases the likelihood of false positive results, which must then be explained to an apprehensive community.

In this case, many ill persons noted a smell at the school on the first day of the epidemic. There was no consistency in the reported quality or location of the odor. Many persons who did not become ill, including school administrators and emergency personnel, also noted an odor on the first day of the outbreak, though it was not consistently described by this group either. The pattern of illness in the school did not reflect a particular route of air distribution. It is difficult to conceive of any toxic gas or other toxic substance in the environment that would account for such variations in the description and location of the odor and for such a wide range of self-limited symptoms in persons scattered throughout a large building, with no evidence of abnormalities in any environmental or laboratory tests.

Rash has been reported in several outbreaks of mass psychogenic illness.[1,13,17] The rash often occurs on exposed skin in a distribution that suggests scratching as the cause.[13,17] In this outbreak, rashes were not consistent among those reporting them, and they were not suggestive of exposure to a particular toxic substance.

The costs associated with outbreaks of mass psychogenic illness have not been extensively studied.[1] The costs that could be quantified in this case were substantial, and they represent an underestimate of the overall resources expended. For example, labor and equipment costs incurred by government agencies and laboratories that participated in the investigation are difficult to assess. In addition, the costs of disruption to the community are difficult to quantify, but they can be substantial.

Outbreaks of mass psychogenic illness are probably more common than currently recognized. When an outbreak of mass psychogenic illness is described to an audience of experienced public health professionals, the consistent response is an outpouring of similar "war stories." Mass psychogenic illness should be considered in any outbreak of acute illness thought to be caused by exposure to a toxic substance but with minimal physical findings and no environmental cause that is readily apparent to the investigators.

Many public health professionals acknowledge that, before embarking on an investigation, they have had a strong sense that an outbreak was psychogenic but that because of intense anxiety in the community, they felt obliged to pursue the investigation beyond what they thought was necessary. It is very difficult — if not impossible — to prove beyond any doubt that a toxic exposure has not simply escaped detection. In this case, three senior officials in the state health department independently suggested mass psychogenic illness as the likely cause before the full investigation was launched. During the investigation, some news reporters, school administrators, and students suggested that the outbreak had a psychogenic component, although such views were never widely publicized. There are no pathognomonic indicators of mass psychogenic illness. Establishing the diagnosis often entails ruling out a long list of potential, sometimes far-fetched, causes. Extensive investigation is often necessary before officials are willing to inform an anxious community of the diagnosis.

With any approach to mass psychogenic illness, the goal should be to restore the community to normal functioning as quickly as possible. Prompt public identification of episodes of mass psychogenic illness has been advocated as an important step in terminating them,[8,18] but such an approach can be problematic in practice. Physicians and others are understandably reluctant to announce that an outbreak of illness is psychogenic, because of the shame and anger that the diagnosis tends to elicit. In this instance, a multiagency environmental response was already under way at the time of the epidemiologic investigation, making such an approach untenable. Public announcements that the various tests were normal and that the school was safe were made without any references to the episode as psychogenic, and the outbreak subsided. Either approach may be met with anger and mistrust on the part of the community.

Alleviation of the widespread anxiety surrounding an episode of mass psychogenic illness requires prompt recognition and a coordinated multiagency investigation. As fears about bioterrorism increase, the frequency of such incidents and the anxiety they generate may increase. Awareness of the characteristics of mass psychogenic illness is critical for physicians and other health care personnel who respond to such outbreaks.

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